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10 November 1976

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SONAR TEST AND TEST INSTRUMENTATION SUPPORT

Quarterly Progress Report No. 1 under Contract N00140-76-C-6487
1 June - 31 August 1976

Dudley D. Baker et al.

NAVAL UNDERWATER SYSTEMS CENTER
Contract N00140-76-C-6487

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AUSTIN, TEXAS 78712

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TABLE OF CONTENTS

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I. INTRODUCTION

Applied Research Laboratories, The University of Texas at Austin (ARL/UT), was awarded Contract N00140-76-C-6487, sponsored by the Naval Underwater Systems Center, New London Laboratory (NUSC/NL), effective 1 June 1976. Some of the work under this contract represents a follow-on effort to previous work sponsored by NUSC/NL under Contract N00140-74-C-6316.

The work under Contract N00140-76-C-6487 is divided into six task areas that focus on technical support in areas of sonar technology:

I. AN/FQM-10(V) Sonar Test Set Field Support

II. Transducer Repair Facility Test Site Field Support

III. AN/WQM-5 Sonar Test Set Field Support

IV. Special Purpose Passive Sonar Systems Support

V. Sonar Instrumentation Test and Evaluation

VI. Study of Towed Line Array Acoustical Testing at Transducer Repair Facilities

This report is Quarterly Progress Report No. 1 under Contract N00140-76-C-6487. Chapter headings in this report correspond to the six task areas. An additional chapter on documentation support is included. Another chapter deals with the procurement of AN/WQM-5 components and field change kits.

II. AN/FQM-10(V) SONAR TEST SET FIELD SUPPORT

A. Introduction

ARL provides direct material and technical support for six AN/FQM-10(V) sonar test sets located at three Naval shipyards with Transducer Repair Facilities (TRFs): Naval Shipyard, Portsmouth (NAVSHIPYD PTSMH), Naval Shipyard, Mare Island (NAVSHIPYD MARE), and Naval Shipyard, Pearl Harbor (NAVSHIPYD PEARL). In addition, ARL maintains a pilot AN/FQM-10(V) at its Lake Travis Test Station (LTTS).

This work is a continuation of previous efforts at ARL under Contract N00140-74-C-6316, Task 0001AA. The quarterly progress reports issued under that contract are applicable references for the present work.

B. Visit to NAVSHIPYD PEARL

In response to a request for technical support, Gary Warren and Terry Gaus of ARL traveled to the TRF at NAVSHIPYD PEARL on 14-25 June. During their visit, they checked out and repaired equipment in the AN/FQM-10(V) ser No. 3 (at the wet slip facilities) and ser No. 4 (at the test tank).

1. Each of the sampling digital voltmeters (SDVM) (unit No. 74) at the AN/FQM-10(V) ser No. 3 and ser No. 4 were repaired and calibrated.

2. A malfunctioning capacitor (C30) in the -28 V power supply of the EI normalizer (unit No. 13) at the AN/FQM-10(V) ser No. 3 was replaced and the unit was aligned and tested for proper operation.

3. The pulse vector immittance meter (PVIM) (unit No. 27) at the AN/FQM-10(V) ser No. 3 was aligned after all wafer switches had been cleaned. The unit was checked out and was determined to be performing as it should be.

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4. Two differential preamplifiers (unit No. 6) were calibrated when an inconsistency was discovered in the gain stages. One of the amplifiers was in the supply of spare parts; the other was in the AN/FQM-10(V) ser No. 4.

5. Because moisture was collecting in the relay on one CML power amplifier (unit No. 65) at the AN/FQM-10(V) ser No. 3, a shutdown in high voltage was occurring. The present method of cooling the amplifiers uses ambient air, which is quite humid. Thus, a recommendation was made to modify the structure housing the amplifiers so that dehumidified air could be circulated from the air conditioners in the instrumentation hut.

6. A digital thermometer was installed in each of the two AN/FQM-10 test sets. The probes and cabling for each digital thermometer will be kept inside the instrumentation huts when they are not in use.

C. Support for NAVSHIPYD PTSMH

Upon request, ARL repaired, calibrated, and returned to NAVSHIPYD PTSMH the Tektronix oscilloscope RM564 (unit No. 44). ARL also delivered to the shipyard one low voltage regulator relay (K-403) and two 100 kΩ resistors for a CML power amplifier (unit No. 65).

III. TRANSDUCER REPAIR FACILITY TEST SITE FIELD SUPPORT

A. Introduction

ARL provides material and technical support for the TRF test sites at three naval shipyards: NAVSHIPYD PTSMH, NAVSHIPYD MARE, and NAVSHIPYD PEARL.

This work is partially a continuation of previous efforts at ARL under Contract N00140-74-C-6316, Task 0001AA, and the quarterly progress reports issued under that contract are applicable references for the work now continuing under Contract N00140-76-C-6487.

B. MX-9818/GQM-1 Adapter, Filling Fixture, Transducer

Filling fixture ser No. A1 was shipped to Stanford Research Institute (SRI) for acceptance testing. The fixture contains all modifications and will be forwarded to the TRF at NAVSHIPYD MARE when the fixture has been accepted by SRI.

Filling fixtures ser No. A2 and ser No. A3 are now under construction and will be completed for shipment in October 1976.

C. Transducer Positioning Systems

1. Background

The testing of sonar transducers as performed by the TRFs is dictated by the "Compendium of Test Requirements and Operating

Characteristics for NAVSEA Sonar Transducers" (NAVSEA 0967-LP-410-2020). The intensive testing procedure performed by the TRFs necessarily places much emphasis on the performance and reliability of the transducer positioning system (TPS) on which the transducer is mounted and also defines a unique set of operating characteristics for such a system. The increasing sophistication and greater directivity of sonar systems demand precision azimuth control, while the diversity of sonar transducers requires that the limits on azimuthal sweep be easily and rapidly adjustable. In addition, the extensive use to which a TPS at a TRF is subjected necessitates greater overall reliability. A longer life within specified tolerances before the TPS is overhauled or replaced is also necessary. The design and construction of the TPSs presently in use at the three TRFs do not satisfactorily meet most of these criteria.

To date, very little has been done to develop a light duty (2500 lb (4000 kg) or less) general purpose TPS designed specifically to meet the needs of the TRFs, as determined by the type of transducer testing being performed at these sites. The existing light duty positioners at the TRFs, which have been in service for 10 to 35 years, are of diverse design. In addition, they may not be suited to the digital control to be provided by the AN/FQM-( ). As a result, the list of existing hardware deficiencies at the TRFs requiring immediate action (see enclosure No. 1 to the minutes of the NAVSEA Sonar TEchnical Support Program (STEP) Working Group Meeting No. 19) includes four TPSs for NAVSHIPYD PTSMH and two TPSs for NAVSHIPYD PEARL. On 3 June 1976, ARL was directed by NAVSEA Code 06H4D to provide two TPSs to NAVSHIPYD PTSMH by October 1976. Due to anticipated delays in procuring certain items, mainly motors and worm drive reducers, the delivery date of the TPSs has been delayed to February 1977.

The techniques employed by ARL personnel in the design and fabrication of the TPSs are intended to fulfill certain "human engineering"

objectives as well as the requirements for the TPS. That is, the TPSs should be easy to use, accurate, long lived, and economically efficient in both initial cost and operator time. Personnel at the TRFs are being sent copies of the design drawings as they are completed; correspondence has resulted in valuable feedback and alterations while the system is still in design. This exchange is expected to continue; ultimately, when the first TPS is installed at the NAVSHIPYD PTSMH TRF, the TRF mechanics will critique the device under actual operating conditions and make recommendations which will likely result in design changes in the remaining units of the TPS.

2. Design Parameters

The TPS, as a part of the Acoustic Test Tank Facility, NAVSHIPYD PTSMH, will be located in the tower and tower supports of the tank/walkway. There will be two vertical shafts, with lifting capacities of 500 lb (800 kg) and 1500 lb (2400 kg), respectively. The system will be installed ready for use with the AN/FQM-10(V) sonar test set and will be easily modifiable for use with the AN/FQM-( ).

Shaft position is monitored and controlled from the AN/FQM-10 by means of a Scientific-Atlanta positioner control system model No. 4161. This system requires use of 115 Vdc motors, 0.75 hp maximum, in the positioner unit proper. All motors employ failsafe brakes. Design life is 10 yr minimum before overhaul, with an expected average life of 50 yr.

Each shaft is capable of operating in any one of three modes. The "normal" operating mode utilizes a baseplate assembly bolted to the tower support pads located approximately 9 ft (2.75 m) above the walkway. A "lowered" operating mode is created by placing the baseplate assembly directly on the walkway, to be used only if the baffles are installed at the bottom of the tank. An "intermediate" mode is possible by mounting the baseplate on an existing 4 ft (1.2 m)

high cart, which operates on a track. Thus, in the intermediate mode, the test distance can be changed.

Preliminary design and conceptualization has produced the following specifications. Bracketed values apply to the 500 lb (800 kg) shaft when the value is different from that of the 1500 lb (2400 kg) shaft; otherwise, the specifications shown apply to both shafts.

Vertical Translation

Capacity:	1500 lb (2400 kg) [500 lb (800 kg)]
Range:	27 ft (8.23 m)
Normal operating mode:	+7 to -20 ft (+2.13 to -6.1 m)
Lowered operating mode:	-1 to -28 ft (-3.05 to -8.53 m)
Intermediate operating mode:	-20 to -25 ft (-6.1 to -7.62 m)
Limits:	Adjustable to any two points within a 32 ft (9.75 m) range
Speed:	7 ft/min (2.13 m/min) maximum, 0.14 ft/min (4.3 cm/min) minimum (14 ft/min (4.27 m/min) maximum 0.28 ft/min (8.5 cm/min) minimum), continuously adjustable
Positioning Accuracy:	±1.5 in. (±3.8 cm)
Synchro Takeoff:	Elevator winch drum (1 drum revolution/2 ft (0.61 m) shaft translation)
Synchro Output:	1:18 (1 synchro revolution/36 ft (11 m) shaft translation)

Rotation

Torque:	270 in.-lb (30.5 N-m)
Range:	5 revolution, ±2.5 revolution
Limits:	Adjustable, any sector within 5 revolution range

Speed:	8.75 rpm maximum, 0.175 rpm minimum, continuously variable
Backlash:	±0.125°
Repeatability	±0.5°
Synchro Takeoff:	Keyed shaft, spring loaded shaft collar
Synchro Output:	36:1, 1:1 AN/FQM-10(V) 6:1, 1:6 AN/FQM-( )

Presently, 90% of the design and assembly drawings are completed. Work is proceeding on subassembly and detailed parts drawings. Since nearly all the bids for long lead items have been received, these items will be ordered shortly.

IV. AN/WQM-5 SONAR TEST SET FIELD SUPPORT

A. Introduction

Naval Sea Systems Command (NAVSEA) assigned ARL the responsibility of being the designated overhaul point (DOP) for repairing AN/WQM-5 components. In addition to being the DOP, ARL will also provide field maintenance engineering support for the 27 AN/WQM-5 test sets located at various naval shipyards and laboratories.

During this report period, ARL has provided support for several of the test sets, as described in the following subsections.

B. AN/WQM-5, Ser No. A4, Test Set

NUSC/NL sent the readout monitor (ROM) (unit No. 1) from their Ser No. A4 test set to ARL to be repaired. Printed circuit (P.C.) board No. 1A-7 was replaced and the -15 V supply wire to P.C. board No. 1A7 was repaired. The input signal terminal behind connector No. J5 was rewired and inductor No. L1 on connector No. P8 was reconnected. A loose wire at switch No. S3-B-1 was resoldered and transformer No. T1 was remounted. The unit was calibrated and shipped back to NUSC/NL.

C. AN/WQM-5, Ser No. A6, Test Set

Upon request, ARL furnished the Naval Shipyard, Long Beach (NAVSHIPYD LBEACH) with one P.C. board No. 7A9 and one P.C. board No. [illegible]A3 for the AN/WQM-5, ser No. A6.

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D. AN/WQM-5, Ser No. A9, Test Set

Two faulty output P.C. boards (No. 8A2) were replaced in the amplifier (unit No. 8) of the AN/WQM-5, ser No. A9, test set at the TRF at NAVSHIPYD PEARL. The insulation of a coaxial cable was penetrated by the sharp end of a wire wrap post, causing the impedance readout of the ROM to display all 0's. The bundle of wires containing the coaxial cable was rerouted to eliminate the problem. The test set was checked out and was determined to be performing as it should.

E. AN/WQM-5, Ser No. A13, Test Set

The ROM (unit No. 1), ser No. A13, from Mobile Technical Unit No. 6 (MOTU 6) in Naples, Italy, was sent to ARL for repair and calibration. The unit was cleaned and inspected visually for obvious failures. Wiring at connectors No. J7 and No. J9 was repaired. Switch No. S8, transformer No. T2, and power supply No. PS2 were replaced when they were found to be faulty. A coaxial cable from the delay potentiometer was replaced. The unit was calibrated and shipped 6 July 1976 via Military Airlift Command (MAC).

After the ROM arrived in Naples, it did not work properly when it was interconnected with the remainder of the AN/WQM-5 test set. The problem could not be localized by the personnel operating the test set and a request for technical aid was sent to ARL. Gary Warren of ARL traveled to Naples to help get the ROM back in operation and to calibrate the test set. This trip will be reported in the next quarterly progress report.

F. AN/WQM-5, Ser No. A21, Test Set

The AN/WQM-5, ser No. A21, test set was received from NUSC/NL and was refurbished at ARL. The test set was then sent to MOTU 5,

San Diego, California, where it will replace their ser No. A15. MOTU 5 will ship the ser No. A15 test set to ARL to be refurbished.

G. AN/WQM-5, Ser No. B1, Test Set

Acting as an emergency supplier, ARL mailed one printer ribbon and one roll of printer paper to the MOTU 4, New London, Connecticut, custodian of the AN/WQM-5, ser No. B1, test set.

V. SPECIAL PURPOSE PASSIVE SONAR SYSTEMS SUPPORT

This task was not funded in the original contract but was funded late in July 1976. Thus ARL did not work on this task during this report period. It is expected that work will begin early in September 1976.

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VI. SONAR INSTRUMENTATION TEST AND EVALUATION

A. Introduction

ARL participated in two projects under this task. The first project was the first article testing, at the Lake Travis Test Station (LTTS), of the AN/WQM-7 Sonar Test Set, previously called the Sonar Test and Evaluation Equipment (STEE). This testing is described in section VI.B. The second project, described in section VI.C., was a feasibility study designed to locate a suitable replacement for the outdated AN/SQM-5 Sonar Noise Recorder.

B. Operational Testing of the AN/WQM-7 Sonar Test Set

ARL conducted tests on the AN/WQM-7 Sonar Test Set during 17 June - 16 July 1976. These performance tests were conducted with the AN/BQR-2, AN/BQA-8B, and AN/WLR-12 sonar systems aboard ARL's STEP Barge located at LTTS. Two reports concerning these tests were generated during this report period. The first report, a preliminary report (ARL Technical Letter TL-EA-76-8 of 28 July 1976), contains most of the comments concerning the system and is included as Appendix A of this report. The second report was a classified report (ARL Technical Letter TL-EA-76-11 of 27 August 1976) and was forwarded to NAVSEA by ARL ltr Ser E-174 of 27 August 1976.

The equipment was deficient in several categories. The primary deficiency was in the configuration of the system, which used a military computer. Because the hardware has to be carried up and down ladders, through hatches, and along narrow walkways, it needs to be fairly lightweight and easy to carry. The present system is not portable, mainly because it is too heavy. For example, one

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unit in the system weighs 120 lb. Any attempt to reduce the weight of the hardware would be complex.

A programmable calculator such as the Hewlett-Packard 9825 or the Wang model No. 2200 would provide the necessary portability and flexibility. Either of these calculators can perform the functions required for the AN/WQM-7 test set and already include the magnetic tape cassette drive and the printer, which are separate instruments in the STEE system. It appears that the only function which cannot be reasonably accomplished with such a calculator is the fast Fourier transform (FFT) algorithm. This algorithm could be accomplished much more effectively by using a real-time spectrum analyzer, which would be able to exactly duplicate the operation of the AN/BQR-20 that the FFT was designed to check.

There are several advantages to having such equipment. The calculators are presently available and would require no additional packaging to make them usable in the system. The cost for such a system would be considerably lower than the cost of the AN/WQM-7 test set system as it is configured. Operational performance would be improved, and the equipment would be easy to use. Furthermore, the flexibility of the calculator's programming ability would allow the test sequence to be modified to compensate for any hardware failures.

Other deficiencies in the AN/WQM-7 test set are in the input signal processing hardware, as reported in Appendix A. Also, the printer and the plotter are very poor and expensive choices for peripheral hardware. These functions could be performed at a substantially reduced cost with off-the-shelf peripherals for a calculator.

One positive aspect of the AN/WQM-7 test set is that the software written for this system followed a well-structured format and was well

documented, even though it was not very flexible in terms of operator use.

C. AN/SQM-( ) Feasibility Study

The goal of this study was to examine currently available programmable calculators (small computers) to determine whether they can be fitted with suitable peripheral units so that they can perform the functions of the AN/SQM-5 Sonar Noise Recorder. One of the problems with the AN/SQM-5 has been its poor maintainability; repair parts are unavailable because the manufactuer is out of business. The AN/SQM-5 is a specialized analog instrument, typical of test equipment used for acoustical measurements five to ten years ago. Adapting a programmable calculator to develop an AN/SQM-( ) recording set would make use of modern general purpose digitial instruments rather than specialized analog units.

ARL began work on the study in June 1976. A specification regarded as a design goal was received on 1 August 1976 from NAVSECNORDIV. Arrangements were made to borrow an AN/SQM-5 from NAVSECNORDIV and the AN/SQM-5 was received on 4 August 1976. By 15 August 1976, a tentative design concept, functional block diagram, and specification had been assembled (see Appendix B). The design for the replacement of the AN/SQM-5 consists of a commercially available programmable calculator and plotter that will be interfaced to a True rms detector and a solid state synchro-to-digital/digital-to-synchro converter. Commercial versions of the True rms detector and synchro converter that will meet the space and weight requirements of the specification have not yet been identified. Most likely these items will have to be designed and constructed specifically for the AN/SQM-( ) application.

By 31 August 1976, NAVSEA had requested ARL to assemble a breadboard of the proposed unit that could be tested to assure compliance with the specification.

VII. STUDY OF TOWED LINE ARRAY ACOUSTICAL TESTING AT TRANSDUCER REPAIR FACILITIES

No funding has been designated for this task.

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VIII. DOCUMENTATION SUPPORT

A. Introduction

ARL participated in two tasks in the area of documentation support, which focused on producing the Sonar Dome Handbook.

B. Publication of the 1976 Revision of the "Sonar Dome Handbook, Volume V, Submarine Sonar Domes," NAVSEA 0967-LP-412-3050

Processing of the revised Sonar Dome Handbook, Volume V, started in May. Considerable work on rearranging the format to provide good readability and a logical arrangement of material had been completed during the previous quarter; however, the new technical information was not received until 3 May. This timing was unfortunate because personnel engaged in the task had to divide their time equally between working on this document and revising the Compendium instead of doing the work in sequence as originally scheduled. Nevertheless, good progress was made on both projects. Volume V was about 80% complete by the end of this reporting period. The artwork and the text have been essentially completed, but more proofreading, polishing of sentence structure, and final typing are still required. Draft copies were submitted in August 1976 to NAVSEA and NAVSEC for review.

Volume V is being processed on an IBM Mag Card II typewriter; thus, all the text is on memory cards so that further revisions and corrections can be processed with greater speed and accuracy than was previously possible. While the revised data provided by NAVSEC have already been incorporated in the test, the format will probably expose gaps in information and other errors not previously noted. Any further changes or corrections desired by NAVSEA or NAVSEC will be processed as expediently as possible, but the amount of labor required to produce such a large and complex document requires considerable time.

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Reproduction and distribution by approximately 1 October, as desired by NAVSEA, is still possible if the changes and additions that still may be required are not too great. The actual reproduction, collating, assembling, checking, and mailing of 400 copies of a document of this size will probably require about 3 1/2 weeks in ARL's Technical Reports Office.

C. Publication of a 1976 Revision of the "Sonar Dome Handbook, Volume II, AN/SQS-26 Steel and Rubber Sonar Domes," NAVSEA 0967-LP-412-3020

The technical data for revising Volume II of the Sonar Dome Handbook were received in July from NAVSECNORDIV. In preparing the handbook for publication, the Mag Card II is being used because of the advantages it has demonstrated in the processing of Volume V. Another reason it is being used is that the IBM Executive typewriter previously used to prepare the sonar dome handbooks is no longer available for this purpose. Because the data from NAVSECNORDIV were in an easy-to-handle format and because the Mag Card II typewriter will expedite processing, work on Volume II should progress at a rapid rate.

D. Publication of a 1976 Revision of the "Sonar Dome Handbook, Volume IV, AN/SQQ-23 Rubber Sonar Domes," NAVSEA 0967-LP-412-3040

The manuscript for Volume IV of the Sonar Dome Handbook was received by ARL on 9 August 1976. Editing and retyping of this document will begin in the near future.

IX. AN/WQM-5 PROCUREMENT AND FIELD CHANGE PROGRAM

A. Procurement of AN/WQM-5 Series Field Change Kits

ARL has been engaged in the development of a field change program to upgrade the AN/WQM-5 Sonar Test Set, under Contract N00024-75-C-6070. ARL also is obligated, under Contract N00140-74-C-6316, to deliver a fixed quantity of field change kits. These kits, when installed, will result in the proposed nomenclatures AN/WQM-5A, AN/WQM-5B or AN/WQM-5C, depending upon the extent of the changes.

By NUSC/NL letter Ser 316-315 of 23 July 1976, ARL was directed to deliver additional field change hardware under Contract N00140-76-C-6487. This hardware will be procured by ARL and the procurements under the two contracts will be handled simultaneously. The bid package for the items that must be manufactured was distributed to a list of bidders on 27 July 1976. The bid opening was held on 28 August 1976. Award of a purchase order to the selected bidder will proceed as rapidly as possible. Remaining items in the field change kits are off-the-shelf items manufactured by Hewlett-Packard. The total hardware to be delivered by ARL to the Navy under the two contracts is as follows:

10 AN/WQM-5A Field Change Kits
5 AN/WQM-5B Field Change Kits
5 AN/WQM-5C Field Change kits

B. Procurement of an AN/WQM-5A Sonar Test Set for Spain

By the same NUSC/NL letter (see section A, above), ARL was directed to deliver an AN/WQM-5A Sonar Test Set, and a group of selected spare parts, to the Spanish Navy. ARL initiated a procurement to the original

AN/WQM-5 manufacturer (Dranetz Engineering Laboratories) for all components of the original AN/WQM-5 that are retained in the new AN/WQM-5A configuration. A purchase order was awarded on 28 July 1976 and delivery is expected in April 1977. To complete the test set, ARL will purchase one additional AN/WQM-5A field change kit in the procurement described in section A, above. The set will be integrated and tested at ARL and then shipped to Spain.

APPENDIX A

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28 July 1976
TL-EA-76-8

PRELIMINARY REPORT

RESULTS OF OPERATIONAL TESTS PERFORMED ON
THE AN/WQM-7 SONAR TEST AND EVALUATION EQUIPMENT (STEE)

T. K. Butler

Operational tests performed on the AN/WQM-7 during June and July 1976 led to the following conclusions.

Weight

The first unsatisfactory aspect of this system is the excessive weight of some of its components. One unit weighs 120 lb but with some inconvenience can be partially disassembled to a backbreaking weight of 104 lb. Since the equipment must be carried down ladders, through hatches and along narrow walkways, a real risk exists for someone to physically hurt himself while handling the heavier units. Experience has shown that a 75 lb weight limit would be desirable for this type of equipment.

Input Configuration

Several unsatisfactory characteristics were noted about the input configuration of the measurement system. The first of these, found simply by looking at the schematics, was that no input protection is provided. CMOS analog multiplexers are used on the STEE input amplifiers. These analog gates are vulnerable to the high voltages found in vacuum tube sonars or they can be blown by high voltage spikes that occur when a sonar is turned on or off. This shortcoming must be corrected in the present system perhaps with blocking capacitors and/or clamp diodes.

The second problem area concerns the differential amplifier input configuration. Each amplifier input is routed to its particular sonar through a 40 ft twinaxial cable (twisted pair with shield). Unfortunately, the low capacitance of this type of cable does not compensate for its

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great length and the resulting capacitive loading at the amplifier inputs reduces common mode rejection and lowers the amplifier's input impedance at high frequencies. These problems are magnified when the cables are driven from a high source impedance. The most satisfactory solution for this problem would be to put the preamplifier in a small housing at the other end of the cable. This is a fairly standard operating procedure in many measurement systems. Such preamplifiers can greatly improve the input impedance and common mode characteristics of the measurement system. Also, since the cables would be driven at low impedance with high level signals, the system becomes much less vulnerable to noise pickup on the cables. An alternate solution would be to use an isolation transformer to provide satisfactory common mode rejection and impedance matching. Finally, it should be mentioned that the coaxial cables and connectors seemed quite flimsy and damage prone; a more rugged substitute should be found.

On the subject of noise, one source of noise in the STEE system was found to be the switching supply that powers the preamplifiers. The switching regulator in this power supply should be replaced with a series regulator to eliminate switching noise from the system.

Another shortcoming with the present input configuration concerns the use of 20 manually controlled amplifiers. The preamplifiers have manual gain controls that are not monitored by the computer. As a result, whenever the gain is changed, the unit must be recalibrated. In actual operation, the operator may inadvertently change the gain and forget to recalibrate. If this happens, the measurement subsequently taken will be entirely incorrect. ARL's experience with such configurations for the gains indicates that, in actual practice, even well-trained operators will fall into the trap of not calibrating after changing the gains.

Still another area where the input processing provided by the STEE system seemed unsatisfactory was the filtering of the signals. The passbands were not flat to within 1 dB and the skirts were, in some

cases, out of specification. Other spectrum analyzers usually have bandpass filters with steeper skirts, sometimes with cutoffs exceeding 120 dB per decade. The use of filters such as the ones in the STEE system will degrade the measurement accuracy and make the measurements prone to contamination from out of band signals.

Along this line, it was found that signals from the AN/BQR-15 and AN/WQC-2 were not processed correctly when taking beam patterns. For example, an AN/BQR-15 beam pattern should be taken with narrowband noise, but STEE uses wideband signals (up to 40 kHz) to make this measurement. In reality, it is often necessary to use some filtering to achieve a satisfactory measurement. No provisions for such filtering are included in the STEE system. This problem requires more attention and should be addressed in the present system.

Finally, the lack of ground isolation between the main console and the remote units is undesirable. Since the units are placed in different locations, differences in ground potential could exist between units. If these voltages are high enough, they could generate errors in the data; if they are excessively high, damage to the circuitry will result. Although differential line drivers and receivers give a measure of protection, optical isolators are much better suited for this application. It should be noted that, during the testing, one of these differential line drivers failed, perhaps for the reason mentioned above.

Miscellaneous Problems

Difficulty was encountered with synchro calibration when the system was in self-test mode. The problem was attributed to overloading of the digital-to-synchro converter. This problem should be corrected.

There is no indicator to warn the operator (or the computer) when clipping of the input signal occurs. Clipping will render incoming data meaningless and unless a warning is issued so that corrective action can

be taken, test results will be useless. The system needs one of these indicators.

The format used for the directivity pattern plots had one shortcoming. Normally the system would put two plots, the beam and the reference hydrophone, together on the same scale. This was done by alternately plotting one signal, then the other, similar to the "chop" mode on a dual channel oscilloscope. Unfortunately, the two plots tended to become jumbled. Something should be done about this problem.

The presentation of the spectral data from the FFT seemed to have scaling trouble. The symptom was the poor amplitude resolution available on the low level scales. Although the problem was not studied closely, it seemed to involve a lack of signal normalization (AGC) prior to A/D conversion. This is surprising since a programmable gain amplifier that should be able to perform this function is available. Perhaps a software change will be all that is necessary to fix this problem.

The bearing accuracy measurement performed by STEE was able to detect sonar misalignment but data that would allow the sonar to be repaired were not made available. This deficiency should be corrected.

Plotter

Another component of the system that seemed less than ideal was the analog plotter. First of all, the plotter is unnecessarily complex and this degrades the reliability of the system. During the tests, several mechanical problems were encountered. Changing the paper on the plotter is a tedious and time consuming operation. Also, the plotter is difficult to adjust; some 20 knobs must be adjusted to calibrate the plotter. This problem is aggravated by the fact that plotter data are not stored within the computer. If the operator incorrectly adjusts a particular knob on the unit, an entire run may be lost. Since these

runs are made by having the submarine travel in a circle, the cost for each run is quite high.

The following corrective measures are recommended. The analog plotter should be replaced with a much simpler and more reliable digital plotter. Also, to reduce the probability of having to repeat submarine runs, the output data should be stored within the computer's memory.

Printer

The printer supplied with the system was found to be unacceptable. When the unit arrived aboard the STEP Barge, it was not operating properly and had to be returned to the factory. A new printer was supplied but it also developed mechanical troubles. In addition to being failure prone, the printer was inconvenient to use because the paper came out upside down. Furthermore, the unit gave off an annoying odor whenever it was operated for any length of time. In the confined spaces of a submarine, this odor would be quite objectionable. Since the commercial printers available on the market are cheaper, more reliable, and more convenient to use, it seems that one of these should be used in the system instead of the existing unit.

System Configuration

The preceding remarks have concerned shortcomings within STEE that must be corrected to bring STEE up to an acceptable performance level. Further modifications, although they may be highly desirable, should not be necessary in order to make STEE workable. The following discussion concerns such a modification: the substitution of a programmable calculator for the computer now used in STEE.

High performance calculators, peripherals, and programmable instruments are all available, off the shelf, for much lower prices than the custom hardware presently used in STEE. One calculator, the HP 9825, features a built-in thermal printer, a built-in cassette tape

unit, and compatibility with a wide variety of peripherals. This calculator could probably handle most of the functions now performed by three of the STEE units (computer, tape, and printer).

In general, calculator programming is done with a high level interpretative language such as BASIC. For a system like STEE, BASIC software would offer several advantages over assembly language programming. First of all, BASIC is a popular and easily learned computer language; thus, BASIC software would be accessible to more people than assembly language code. If the STEE system were to be modified or upgraded at some future date, BASIC software would probably be easy to change. Also, if the software is easy to work with, it can be modified in the field by an engineer to accommodate minor equipment failures or other unusual circumstances. Assembly level programming tends to be less flexible in this regard.

The most serious shortcoming to the calculator approach is that it tends to be slow in performing computations, particularly FFTs. This problem can be eliminated, however, if a real-time spectrum analyzer instead of the FFT algorithm is used to generate the spectra. With the spectrum analyzer, no system degradation would occur if the calculator were used. Also, spectrum analyzers have a real-time display that is very useful for tracking down and eliminating sonar problems. STEE lacks this capability, a fact which became evident when a noise problem arose during the testing at Lake Travis.

Another objection to the FFT concerns the manner in which STEE will evaluate the AN/BQR-20. Real-time spectrum analyzers, like the AN/BQR-20, continuously sample the input data to generate a cumulative output. On the other hand, the FFT algorithm processes data in "chunks." Input data is sampled for a certain length of time and is processed afterwards. Unfortunately, the processing phase usually takes much longer than the sampling phase; consequently, most of the input data is ignored. It is easy to conceive of a situation in which STEE would

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gather a set of data that was quite different statistically from the data acquired by the AN/BQR-20. Any comparisons between the outputs of the two systems would be questionable under these circumstances. Clearly, the best way to test the AN/BQR-20 is with another real-time analyzer, not an FFT based system.

Software

It should be mentioned that the software approach used in STEE seemed to be quite good. The programs performed nicely and apparently met the specification. During the testing, some inconsistencies were noted in the presentation of data and status information. Also, the notation used to refer to the various input channels was ambiguous. For example, the operating manual might refer to Channel 6, while the computer would refer to the same channel as Channel 5. These ambiguities should be cleared up to minimize operator confusion.

Summary and Recommendations

It is recommended that the following problems be corrected before further evaluation of STEE: (1) the input protection of the input analog switches; (2) the input noise of the STEE system; (3) the band-pass filter responses; (4) the elimination of the switching power supply used with the input amplifier; (5) isolation of the grounds between the various chassis so that ground currents between the systems cannot damage the units or cause problems with noise; (6) inability of the computer to read the gain settings of the manually controlled pre-amplifiers; (7) lack of filtering for AN/BQR-15 beam patterns; (8) digital-to-synchro converter output level; (9) lack of a clipping indicator; (10) faulty plotter; (11) faulty printer; (12) ambiguities in system notation; (13) poor beam pattern format; (14) lack of AGC on FFT; and (15) bearing accuracy test deficiency.

Considerable difficulty was encountered with the ping receiver; the unit did not work properly and the controls were difficult to operate. Considerable attention should be given to this device.

Future systems similar to STEE should be built around calculators instead of computers. The advantages of calculators are numerous: (1) lower hardware costs; (2) lower software costs; (3) off the shelf availability of hardware; (4) lower weight; (5) smaller size; (6) easier installation; (7) easier operation; (8) greater flexibility; (9) greater reliability; and (10) fault tolerance.

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APPENDIX B

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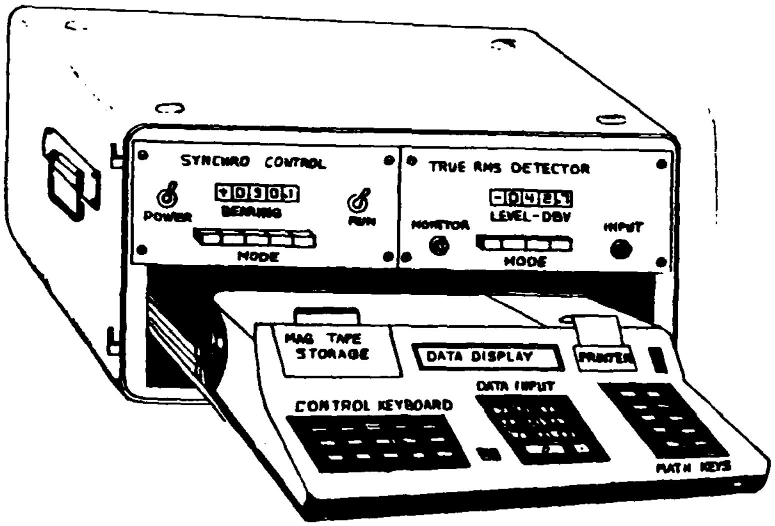
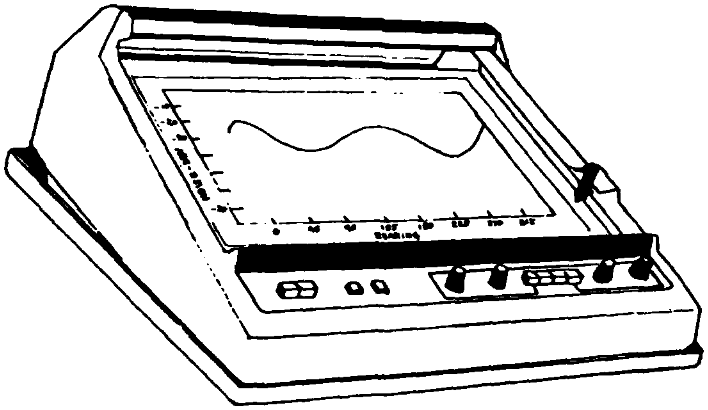
DESIGNERS CONCEPT -- SONAR NOISE RECORDER AN/SQM-( )



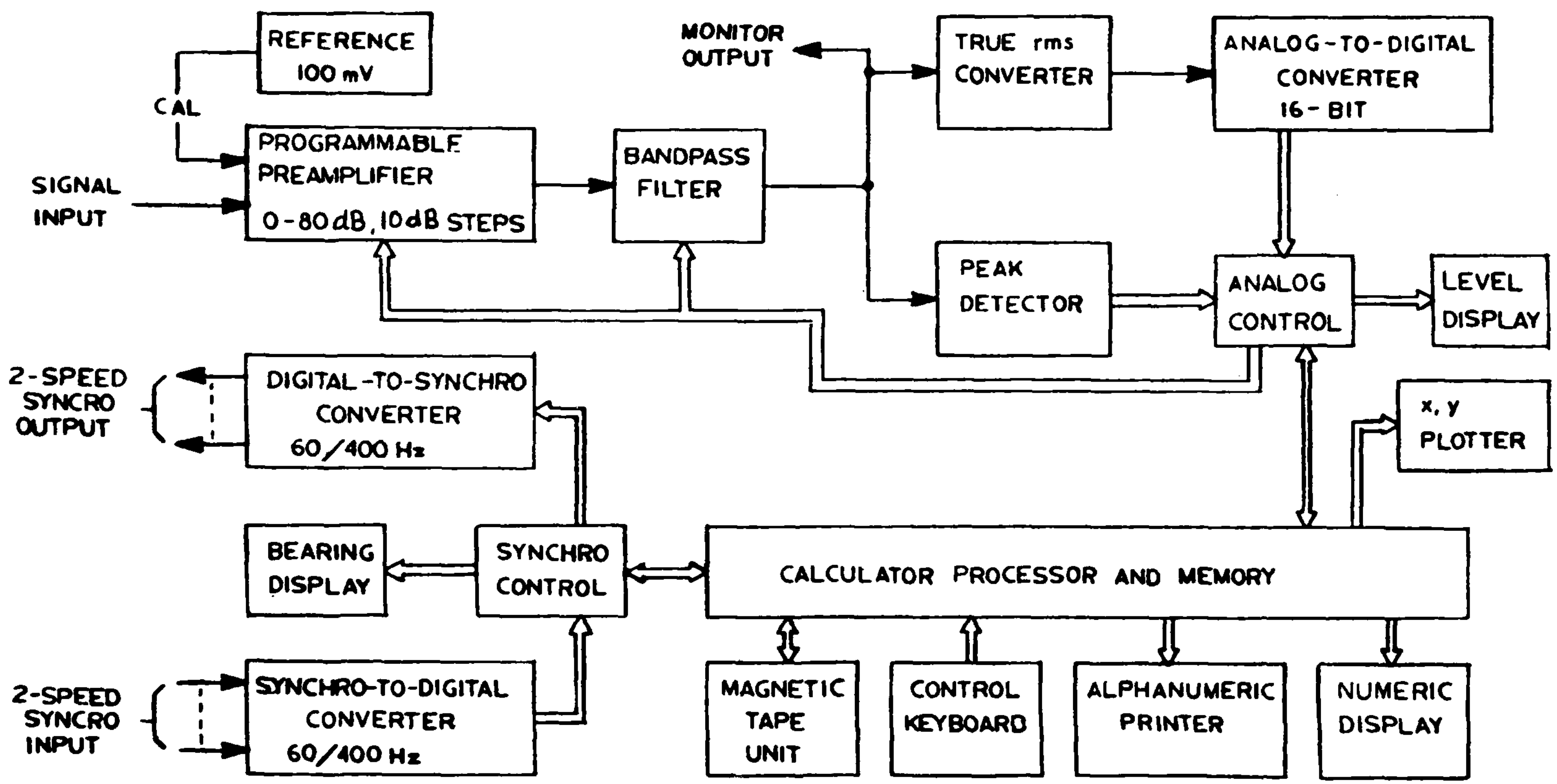
CONTROL UNIT



x, y PLOTTER

FUNCTIONAL BLOCK DIAGRAM

SONAR NOISE RECORDER AN/SQM-( )



TENTATIVE SPECIFICATIONS -- SONAR NOISE RECORDER AN/SQM-( )

Analog Section

Full Scale Ranges:	1 mV to 10 Vrms in 10 dB steps
Response Time:	Fast response -- 10 msec Medium response -- 40 msec Slow response -- 100 msec
Frequency Range:	Fast response -- 1 kHz to 30 kHz Medium response -- 500 Hz to 30 kHz Slow response -- 150 Hz to 30 kHz
Reading Accuracy:	±5% of reading ±.01% of range
Crest Factor:	8 to 1 for 1.0% reading error
Input Impedance:	>10 MΩ, 22 pF shunt
Maximum Input Voltage:	±200 V peak
Filters:	Low Pass -- 30 kHz High Pass -- 150 Hz
Roll off:	12 dB/octave
Internal Calibrate Signal:	100 mVrms ±1%

Synchro Control

Reference Input:	60 or 400 Hz
Synchro-to-Digital Accuracy:	Dual-speed mode -- ±0.1° Single-speed mode -- ±1.0°
Range:	000.0° to 359.91°
Speed:	up to 10°/sec

Digital-to-Synchro	
Accuracy:	±0.1° 1X and 36X
Range:	000.0° to 359.9°
Speed:	30, 60, 120, 240, 480, 960 sec/360°
Start/Stop Bearing:	Programmable to 0.1°

Plotter Formats

x,y Plots:	x axis, bearing, 0 to 360°
	y axis, True rms noise amplitude in dB, 6 in. scale, 10 dB/in.
Polar Plots:	10 dB/in.
Variable Format:	Noise in a selected quadrant can be plotted as a function of ship's speed. Audio beam patterns could also be plotted.

Control/Computation

Operator Control:	The measurement process is controlled from a single keyboard labeled with the appropriate operator commands.
Data Storage:	Up to 10,000 data points can be stored on magnetic tape.
Data Printout:	An alphanumeric printer is built in. Labeled measurement parameters and data can be easily printed out.

Physical Characteristics

Size:	Two portable units may be required. The control unit would be housed in a case that is approximately 12 in. x 21 in. x 21 in. and weighs 40 lb. The x-y plotter unit would be housed in a case having approximately the same dimensions as the control unit and would weigh approximately 50 lb.

10 November 1976

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UNDER CONTRACT N00140-76-C-6487
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